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PHYSICS.—*An aneroid calorimeter.*[1] H. C. DICKINSON and N. S. OSBORNE, Bureau of Standards.

The term "aneroid calorimeter" is applied to a type of calorimeter in which equalization of temperature is secured by means of the thermal conductivity of copper instead of by the convection of a stirred liquid. The calorimeter consists of a thick walled cylindrical vessel of copper, in the walls of which is embedded a coil of resistance wire to supply heat electrically, and of a platinum resistance coil for use as a thermometer; it has been found useful over a wide range of temperatures and is applicable to a variety of problems.

For use at low temperatures the calorimeter is mounted in a jacket surrounded by a bath of gasoline the temperature of which can be controlled thermostatically to within a few thousandths of a degree at any temperature between −55° and +40°C., or it can be changed rapidly in order to keep it the same as that of the calorimeter when heat is being supplied to the latter. Differences in temperature between the surface of the calorimeter and that of the jacket are measured by means of multiple thermocouples which have ten junctions distributed over the surface of each, thus making it possible to apply accurate corrections for thermal leakage between calorimeter and jacket even when the temperatures of both are changing rapidly.

[1] To appear in the Bulletin of the Bureau of Standards.

The platinum resistance coil (for use as a thermometer) embedded in the calorimeter shows slight irregularities in its behavior, probably due to the difference in expansion between the platinum and the copper which surrounds it. Uncertainties on this account, while in general negligible, can be avoided by measuring the temperature of the outer bath with a standard resistance thermometer, using the thermo-couples to measure the small difference, usually not more than a few thousandths of a degree, between the calorimeter and the jacket. The thermometer could probably be improved by changing the construction.

Results of a series of experiments give the constants of the resistance thermometer and the heat capacity of the calorimeter including a tin lined cell for use in determining the specific heat of ice and water and the latent heat of fusion of ice.

A series of check experiments on the specific heat of water show the order of reproducibility of results, which can be obtained with this calorimeter, to be 1 part in 2000. Measurements made at temperatures between 0° and 40°C. gave results which agree to within the limits of experimental accuracy with the unpublished results of a long series of experiments made in the usual form of stirred water calorimeter. The results are also in satisfactory agreement with the most probable values deducible from the data of the most careful investigations published by other observers.

PHYSICS.—*The specific heat and heat of fusion of ice.*[1] H. C. DICKINSON and N. S. OSBORNE, Bureau of Standards.

Results of previous determinations of the specific heat of ice by certain observers have indicated a rapid increase in the specific heat on approaching the melting point; whereas A. W. Smith[2] has found the heat capacity of ice to be practically constant up to temperatures very close to zero, provided great care and refinement are used to insure the purity of the ice, and that

[1] To appear in the Bulletin of the Bureau of Standards.
[2] Physical Review **17**: 193. 1903.

sensible increases in the apparent heat capacity with ice samples of only ordinary purity are accounted for by the assumption of incipient fusion caused by the lowering of the melting point by the dissolved impurities.

The present investigation has been undertaken with the object of securing further evidence as to the thermal behavior of ice at temperatures near the freezing point, and of obtaining reliable data for the construction of tables of total heat of ice and water in the range of temperature with which refrigerating engineers are concerned.

The measurements were made by means of a calorimeter of aneroid type (i.e., without stirred liquid as calorimetric medium) which is described in detail in the foregoing paper. Briefly described, the tin lined metal cell containing the specimen is enclosed within a shell of copper, the copper acting as the calorimetric medium for transmission and distribution of heat electrically developed in a coil built into the shell. The calorimeter is surrounded by air and enclosed in a metal jacket which is surrounded by a stirred liquid bath, the temperature of which can be controlled within a few thousandths of a degree at any temperature between −55° and +40°C. Measured amounts of heat are supplied to the calorimeter electrically by means of the built-in heating coil. The calorimeter temperature is measured by means of a platinum resistance thermometer also built into the shell. Differences in temperature between the calorimeter and jacket surfaces are measured by means of multiple thermocouples distributed on the surfaces. During an experiment thermal leakage is minimized by keeping the temperature of the jacket nearly equal to the changing temperature of the calorimeter.

The samples used were from 400 to 470 grams each. Three samples were of redistilled water of fairly high purity, while a fourth, which was distilled directly into the container, appeared from the experimental results to have a much higher degree of purity.

In the determinations of specific heat it is found that over the range of temperature covered by the experiments, i.e., −40°

to 0°.050C., the specific heat, S, in 20° calories at any temperature θ, of the four ice samples is represented within the limit of experimental error by the equation:

$$S = 0.5057 + 0.001863\,\theta - 79.75\,\frac{l}{\theta^2}$$

in which the constant l is assumed to represent the initial freezing point of the specimen and has the following values:

Sample	l
1	0.00125
2	0.00120
3	0.00095
4	0.00005

From the fact that the term which represents the departure of the specific heat from a linear function of the temperature is found to depend on the purity, being less the purer the ice, it is concluded that the specific heat of pure ice in 20° calories may be closely represented by the equation:

$$S = 0.5057 + 0.001863\,\theta$$

Determinations of the heat of fusion made upon three of the samples used for the specific heat determinations gave the folowing values:

Sample No.	*Heat of Fusion* Cal$_{20}$/g
1	79.68
2	79.85
4	79.75
Mean	79.76

The results of a previous investigation at the Bureau of Standards, using very different methods to determine the heat of fusion of ice, give when corrected for the newly found value for specific heat a mean value of 79.74 20° calories per gram. The mean for the two investigations is: 79.75 20° calories per gram. For the use of engineers a table of total heats of ice and water is given expressed in B.t.u. per pounds at temperature from −20°F. to +100°F.

PHYSICS.—*Covellite: A singular case of chromatic reflection.* H. E. MERWIN, Geophysical Laboratory.

To describe and to account for some striking color changes in covellite when it is immersed in colorless inert liquids of different refractions is the object of this study.

Covellite, crystalline cupric sulphide, in finest powder is very dark blue; brilliant crystal surfaces or polished plates, whether obliquely or vertically illuminated, are lighter, and vary noticeably in color with differences in crystallographic section. In obliquely incident daylight a plate, parallel to the cleavage, immersed in alcohol (refractive index, $n = 1.36$) appears brilliant purple,[1a] in benzene ($n = 1.50$) it appears reddish purple,[1b] and in methylene iodide ($n = 1.74$) it appears red.[1c] A plate perpendicular to the cleavage changes only to purple in methylene iodide.

Natural crystals have not yielded flakes thin enough to transmit sufficient light for optical study but some synthetic crystals prepared in this laboratory by E. G. Zies and by Eugene W. Posnjak were found suitable for microscopic study. These crystals are hexagonal scales or piles of scales reaching 0.5 mm. in diameter, and 0.002 mm. in maximal thickness. The thicker plates transmit scarcely perceptible amounts of light even when illuminated by direct sunlight, the thinner ones are yellowish green[2] to dark olive. By both a spectrometer eye-piece and a prism monochromatic illuminator the yellowish green color was found to be caused by less transmission of the red and violet than of the middle of the spectrum. The fall in relative transmission from green to violet—at least as far as 410$\mu\mu$—is not apparently very great; it is greater in the red from about 630 to 700$\mu\mu$ mm. The transmission is shown in a general way in figure 1.

Plates probably not exceeding 0.0005 mm. in thickness served

[1] The colors were compared with Ridgeway's standards. Although the standards are less brilliant approximate matches were made. (a) Between violet-purple and true purple. (b) Near rhodamine purple. (c) Between spectrum red and rose red.

[2] E. Weinschenk prepared similar plates and noted the red color reflected after mounting in Canada balsam. Z. Kryst., **17**: 497. 1890.

for determinations of refractive index.[3] The following observed values are plotted in figure 1:

wave length $\mu\mu$	*refractive index* n
635	1.00
610	1.33
589	1.45
570	1.60
520	1.83
505	1.97

Different directions in the plane of the plate give the same value.

Between crossed nicols, flat-lying plates appear dark and exhibit no distinct interference figure. Yet tilted plates are doubly refracting and pleochroic. One ray vibrates in the plane of the plates and is darker for all colors. For both rays there appear to be regions of much stronger absorption at both ends of the visible spectrum. These are closer together for the ray vibrating in the plane of the plates.

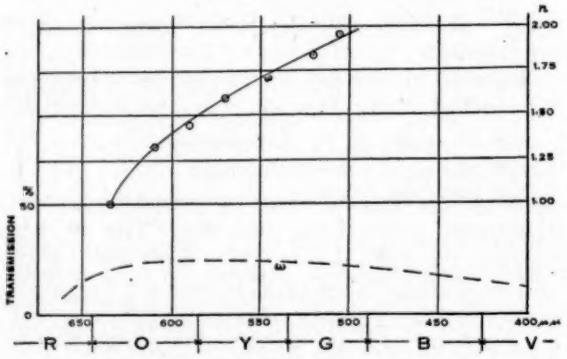


Fig. 1

[3] Practically opaque plates, measured with the micrometer caliper, were only 0.002 mm. thick. Moderately transparent plates were so thin that the displacement of the bright border of light produced in determining the refractive index was so slight that high magnification and a very perfect fine adjustment screw were required to make the displacement evident. Even then differences of less than ± 0.03 in refractive index could not be detected, owing partly to diffraction. In many plates the diffraction bands entirely obscured the phenomena of refraction. The method finally pursued involved the use of a monochromatic illuminator. Only such plates were used as showed a pronounced reversal of the position of the bright border for wave-lengths about 10 μ greater or less than that for which the determination of refractive index was made.

Absorption is so strong that the color of covellite even in the finest powder is due to light reflected directly from the surfaces of grains. Yet differences in absorption of different colors are not sufficient to cause marked differences in the reflection of these colors. Therefore we look to the refractive index and reflective power to explain the color effects already described.

I have estimated that for light from orange to violet which enters the surface at normal incidence about one-fourth is transmitted by a plate 0.5 μ thick. For these colors the absorption index, κ, is of the order of 0.1; for red it may have twice[4] this value. Absorption has, therefore, very little effect upon the reflective power of the mineral in the visible spectrum. The reflecting power, R, represents the reflected fraction of the normally incident light as given by the equation

$$R = \frac{n^2\kappa^2 + (n-1)^2}{n^2\kappa^2 + (n+1)^2}$$

in which n is the refractive index for the wave-length having the absorption index (extinction coefficient) κ. The following equations define κ:

$$I = I_1 e^{\frac{-4\pi n \kappa d}{\lambda}} \quad ; \text{ or } I = I_1 e^{\frac{-4\pi \kappa d}{\lambda_1}} \qquad (1)$$

The intensity of the light entering the surface is I_1. After traversing the distance d the intensity is I. The wave-length of the incident light in the ether is λ. The other symbols have their usual significance. λ_1, is the assumed wave-length within the absorbing medium. If I and I_1 represent amplitudes of vibration then the exponent of e becomes $\frac{-2\pi n \kappa d}{\lambda}$. These equations define κ according to the usage of most of the recent writers. Yet in the following physical tables both the name and the definition of this symbol vary. In *Tables Annuelles Internationales*, page 133, for 1912, names and definition are as above; in *Landolt, Börnstein and Roth*, page 966 (1912) the symbol k, called the absorption index, $= n\kappa$ above; in *Smithsonian Physical Tables*, page 195 (1914) first two equations, k, called the absorption index, $= \kappa$. Also in Wood's *Physical Optics* (1911) in the chapter on the optical properties of metals κ is named and defined as above, but in the chapter on the theory of dispersion $= n\kappa$ above.

For values of $n < 3$ the reflective power increases much faster than n. For white light incident from air at an angle of 60° on plates cut parallel to the cleavage about 20 per cent of the blue

[4] Or several times, for W. W. Coblentz found very high reflecting power in the near infra-red on an inclined section (Carnegie Inst. Wash. Pub. 97).

and violet light is reflected;[5] 15 per cent of the green; 12 of the yellow; 5 of the orange; and none of the red. The resulting color is blue. At angles less than 60° the colors are reflected in about the same proportions as at 60°. At larger angles blue and violet are less dominant.

Light incident at 60° from water has a little more than half as much of its green, blue, and violet reflected as in case of air; and *all of the red and about half of the orange is entirely reflected*, because the angle of incidence is greater than the critical angle. Yellow is reflected scarcely at all because for it, water and covellite have nearly the same refractive index. As the angle of incidence decreases orange and then red cease to be totally reflected, but the relative proportions of the other colors do not change greatly. For more oblique rays total reflection extends a little further into the orange. The total color effect is purple.

Similarly, oblique reflection from covellite in benzene (n = 1.50) contains still more of the colors of the red end of the spectrum and less of the violet end, and in methylene iodide (n = 1.74) orange is the predominating color. In the latter at 60° only about 5 per cent of the blue and violet are reflected as against 20 per cent in air.

The light reflected in air from surfaces perpendicular to the cleavage is blue, but brighter than from those parallel to the cleavage. This stronger reflection indicates higher refraction for at least the red end of the spectrum. Red is totally reflected at large angles of incidence in liquids of higher refraction than 1.64. Therefore the index of refraction ϵ_{Li} is about 1.5. A large amount of blue is also reflected (not totally) in liquids of even higher refraction, indicating that ϵ for blue must be considerably higher than 1.75. Thus throughout the visible spectrum $\epsilon > \omega$. The differences in color of the light reflected parallel and perpendicular to the cleavage are independent of the pleochroism observed in transmitted light.

[5] Calculated by the formula for transparent substances, for it has already been shown that absorption in this case effects the reflection of different colors about the same amount. The fraction reflected

$$= \tfrac{1}{2}\left\{\frac{\sin^2(i-r)}{\sin^2(i+r)} + \frac{\tan^2(i-r)}{\tan^2(i+r)}\right\}$$

where i and r are the angles of incidence and of refraction, and $\sin i = n \sin r$.

GEOLOGY.—*The calculation of calcium orthosilicate in the norm of igneous rocks.* HENRY S. WASHINGTON, Geophysical Laboratory.

When the calculation of the norm from the analysis of an igneous rock was first worked out some fifteen years ago in connection with the Quantitative System, provision had to be made for magmas so low in silica that there remained a deficit for the femic minerals, after salic potash, soda and lime had been assigned their minimal amounts to form leucite, nephelite and anorthite respectively. Nearly all melilite-bearing rocks and some nephelinites fall under this category. At that time the physical chemistry of the calcium silicates had been scarcely studied and, though the use of calcium orthosilicate was considered, the normative calcium silicate molecule selected was $4CaO.3SiO_2$, as it corresponded to the slag mineral akermanite of Vogt, which is apparently isomorphous with and related to melilite. Equations for the calculation of this molecule in the norm were accordingly given in the publication of the quantitative system.

Subsequently, investigations in the Geophysical Laboratory[1] showed the non-existence of $4CaO.3SiO_2$ but the existence of a compound of the formula $3CaO.2SiO_2$. It seemed probable that this last formula, rather than Vogt's, represented the composition of akermanite. Consequently the new formula was adopted, and a corresponding modification of the norm and its calculation was proposed.[2]

Very recently the study of the ternary system CaO-Al_2O_3-SiO_2 has been completed by Rankin and Wright,[3] who show that the compound $3CaO.2SiO_2$ is unstable and occupies only a small field, while the orthosilicate, $2CaO.SiO_2$, exists in three stable forms, depending on the temperature, and occupies a large field; that is, the orthosilicate may be formed within a much wider

[1] A. L. Day, E. S. Shepherd and F. E. Wright, Am. J. Sci. (4) **22**: 280. 1906; E. S. Shepherd, G. A. Rankin and F. E. Wright, J. Ind. Eng. Chem., **3**: 214. 1911.

[2] Cross, Iddings, Pirsson, Washington, J. Geol., **20**: 558. 1912.

[3] G. A. Rankin and F. E. Wright, Am. J. Sci., **39**: 1. 1915.

range of conditions than the 3:2 silicate. It has therefore been thought best by the authors of the quantitative system to substitute the calcium orthosilicate molecule for that of $3CaO.2SiO_2$. This seems the more advisable, since calcium orthosilicate exists in the mineral monticellite, and is analogous chemically to the ferrous and magnesium orthosilicates, fayalite and forsterite, while $3CaO.2SiO_2$ is unknown in nature.

This change necessitates new equations for the calculation of the norm, and, though these may be figured out by anyone acquainted with the principles involved, it would seem to be advisable to present them. It will, however, be rarely necessary to use them, for among nearly six thousand rock analyses already assembled for a new edition of the *Collection of Rock Analyses*, of which the norms have been calculated, only about 80 are of such low silicity and other chemical characters as to demand the calculation of calcium orthosilicate. It may be remarked that, judging from the cases in which I have had to calculate calcium orthosilicate, the substitution here proposed changes the classificatory position of very few rocks. This is to be expected, as it amounts only to the shifting of a very small amount of silica, and affects only the relation of pyric to olic normative minerals. The present opportunity also permits the illustration of a simplified procedure in calculating the norm which I have finally adopted as most economical of time and labor.

It will be assumed that a preliminary study of the mol numbers and successive trials have shown a deficiency in silica, that is, an amount insufficient to form leucite, nephelite, anorthite, acmite, diopside, and olivine, so that there must be a readjustment of the silica assigned to diopside (and wollastonite), and a certain amount of calcium orthosilicate must be calculated.

The most frequent case is that in which there is no wollastonite, or its amount is insufficient to satisfy the deficit in silica. Here, after allotting SiO_2 to form leucite, nephelite, anorthite, and possibly acmite, the amount thus used is deducted from the total (molecular) amount, the residue being the "available silica." Letting d = molecules of diopside ($CaO.(Mg,Fe)O.2SiO_2$), f = molecules

of olivine ($2(Mg,Fe)O.SiO_2$), and c = molecules of calcium orthosilicate ($2CaO.SiO_2$),[4] we have the equations:

(1) $2d + f + c$ = available silica.

(2) $d + 2f$ = amount of MgO and "residual" FeO.[5]

(3) $d + 2c$ = amount of "residual" CaO.[6]

These equations can be solved, of course, in several ways, but that which I have adopted is as follows: Subtracting (1) from the sum of (2) + (3), we get the value of f + c. Substituting this in (1) d is found and then from (2) and (3) f and c are found successively.

In the second case, where there is sufficient tentative wollastonite to meet the deficiency in SiO_2, the total amount of silica in the rock is subtracted from the sum of the silica which has been allotted to leucite, nephelite, anorthite, diopside, and to tentative wollastonite. The deficit thus shown is the number of molecules of necessary $2CaO.SiO_2$, and also the amount of silica to be assigned for it. This requires twice as much CaO. The rest of the CaO remains in wollastonite and takes an equal amount of SiO_2, while the diopside remains unchanged.

Two examples will be given of the calculation of norms containing calcium orthosilicate, the figures being placed in the positions which they uniformly occupy on the backs of the cards on which the analyses of my collection are written (pages 348, 349).

Regarding the mechanical procedure of calculation, it may be observed that a columnar arrangement and the writing down of all the constituent oxides in the minerals of fixed composition, the feldspars and lenads, acmite, magnetite and ilmenite, recommended in the original publication on the Quantitative System, are time-consuming, and needless after a little practice. I have also, to save time, slightly altered the order of procedure, though this does not depart, in any respect, from the principles on which the calculation of the norm is based. The various molecular

[4] This is represented by the symbol cs, and has a molecular weight of 172.

[5] This is the FeO + MnO remaining after the formation of magnetite and ilmenite.

[6] This is the CaO remaining after the formation of anorthite and apatite (and rarely perofskite).

amounts of the minerals (mostly minor constituents), of fixed composition, as apatite, acmite, magnetite and ilmenite, are first written down, and then the salic K_2O, Na_2O and CaO are assigned to orthoclase, albite and anorthite. Diopside is then formed from the balance of the CaO with an equal amount of MgO + FeO, and the rest of these last two oxides, which are usually in excess over CaO, are assigned to hypersthene, care being taken to have their relative proportions the same in both femic minerals. A slide rule is very useful for this, and for obtaining other ratios. It is to be remembered that only the FeO (+ MnO) remaining after the formation of magnetite and ilemite is to be used, as is seen in the lower left hand corner.

The various amounts of SiO_2 assigned for these various molecules are written down on the right and the sum is compared with the total SiO_2 of the rock. If there is an excess it is calculated as quartz and the other mineral molecules are calculated directly from their molecular amounts by the use of the regular tables. If there is a deficit in SiO_2, the SiO_2 of the tentative hypersthene is subtracted from the sum total of used SiO_2, the balance subtracted from total SiO_2, and hypersthene and olivine formed by

	A	Aa	B	Ba
SiO_2	38.35	0.639	40.15	0.669
Al_2O_3	12.02	0.118	17.32	0.170
Fe_2O_3	3.20	0.020	7.25	0.045
FeO	8.32	0.115	4.00	0.056
MgO	18.70	0.468	4.43	0.111
CaO	9.11	0.163	11.78	0.210
Na_2O	3.15	0.051	5.99	0.097
K_2O	0.84	0.009	3.78	0.040
H_2O	3.26		1.18	
TiO_2	3.02	0.038	3.21	0.040
P_2O_5	0.43	0.003	0.71	0.005
MnO			0.08	0.001
Etc.			0.50	
	100.40		100.38	

A. Nephelinite, Vosges, France. A. Michel-Levy, C. R., CXLVIII, p. 1530, 1909. Aa = mol numbers.

B. Nephelinite, Etinde, Kamerun. E. Esch, Sb. Pr. Ak. W., 1901, p. 415. Ba = mol numbers.

A

an 58 = 16.12

lc 9 = 3.92
ne 51 = 14.48

ap { P_2O_5 3 / CaO 10 } = 1.01

mt 20 = 4.64

il 38 = 5.78

di

CaO 75 = 8.70

MgO 67 = 6.70

FeO 8 = 1.06
16.46

SiO_2 150

ol

MgO 401 = 28.07

FeO 49 = 5.00
33.07

SiO_2 225

cs

CaO 20 / SiO_2 10 } = 1.72

	SiO_2
	116
	36
	102
	254
	639
	385

$2d + f + c = 385$

$d + 2f = 525$

$d + 2c = 95$

$2d + 2f + 2c = 620$

$2d + f + c = 385$

$f + c = 235$

$CaO' = 95$

MgO = 468

FeO = 57
525

d = 75, f = 225, c = 10

B

an 33 = 9.17

lc 40 = 17.44
ne 97 = 27.55

di

CaO 111 = 12.88

MgO 111 = 11.10
23.98

SiO_2 222

CaO for wo = 49

ap { P_2O_5 = 1.68 / CaO 17

wo

CaO 5 / SiO_2 5 } = 0.58

cs

CaO 44 / SiO_2 22 } = 3.78

mt 17 = 3.94

il 40 6.08

hm 28 4.48

	SiO_2
	66
	160
	194
	222
	49
	691
	669
	−22

the equations on page 194 of the book on the system. If there is still a deficit, all the remaining FeO and MgO are assigned to olivine, and the salic Na_2O_2 and SiO_2 divided between albite and nephelite by the equations in (a) on the same page. If there is still not enough SiO_2 to form albite, orthoclase and leucite are calculated, the salic Na_2O being all assigned to nephelite; and if there is not enough SiO_2 for orthoclase, the equations described above are resorted to.

This procedure may seem to be lengthy and complicated, but in reality, after a little experience, knowing the mineral composition of the rock and the amount of SiO_2, it will often happen that a simple inspection will lead one to adopt at once the correct stage of process. Excess SiO_2 is present in the norm of most rocks, except those with modal lenads, occurring not infrequently in those with modal olivine, so that its presence can usually be assumed in such rocks as diorites, andesite, and even not a few basalts. But if, for example, the rock is a nephelite-syenite, tinguaite or tephrite, the presence of normative nephelite may be assumed as probable, and all the excess MgO and FeO assigned at once to olivine. Such facts permit short cuts in the calculation of the norm, and any errors in the assumptions are detected in the calculation.

A table is here given for the calculation of calcium orthosilicate which may be cut out and pasted over that for akermanite in the book, which it replaces.

Calcium orthosilicate, 2 CaO. SiO_2. molecular weight, 172

(Unit of calculation is one-half molecular proportion of CaO)

MOL.	0.000	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009	MOL.
0.00	0.00	0.17	0.34	0.52	0.69	0.86	1.03	1.20	1.38	1.55	0.00
0.01	1.72	1.89	2.06	2.24	2.41	2.58	2.75	2.92	3.10	3.27	0.01
0.02	3.44	3.61	3.78	3.96	4.13	4.30	4.47	4.64	4.82	4.99	0.02
0.03	5.16	5.33	5.50	5.66	5.85	6.02	6.19	6.36	6.54	6.71	0.03
0.04	6.88	7.05	7.22	7.40	7.57	7.74	7.91	8.08	8.26	8.43	0.04
0.05	8.60	8.77	8.94	9.12	9.29	9.46	9.63	9.80	9.98	10.15	0.05
0.06	10.32	10.49	10.66	10.84	11.01	11.18	11.35	11.52	11.70	11.87	0.06
0.07	12.04	12.21	12.38	12.56	12.73	12.90	13.07	13.24	13.42	13.59	0.07
0.08	13.76	13.93	14.10	14.28	14.45	14.62	14.79	14.96	15.14	15.31	0.08
0.09	15.48	15.65	15.82	16.00	16.17	16.34	16.51	16.68	16.86	17.03	0.09

MINERALOGY.—*Bornite as silver precipitant.*[1] CHASE PALMER, Geological Survey.

In an introductory chapter of their studies in silver enrichment Palmer and Bastin[2] by quantitative experiments have shown that chalcocite (Cu_2S) is decomposed completely by a dilute solution of silver sulphate. As a result of this reaction all the copper of the chalcocite enters the solution as cupric sulphate, while free silver and silver sulphide in equivalent amounts are deposited. Many years ago R. Schneider[3] recorded a similar observation on the conduct of cuprous sulphide (Cu_2S) with dilute silver nitrate solution, but inasmuch as other observers have issued conflicting statements concerning the products of the reaction, it seemed advisable to study the reaction anew with silver sulphate solution. According to these recent experiments the proportions of the substances appearing in the reaction between chalcocite and silver sulphate solution may be expressed by the abbreviated equation:

$$Cu_2S + 2Ag_2SO_4 = 2CuSO_4 + 2Ag + Ag_2S.$$

Anthon[4] had observed that by interaction with silver nitrate solution pure cupric sulphide (Cu_nS_n) is changed completely to silver sulphide and soluble cupric nitrate without deposition of free silver and this observation has been repeatedly confirmed by others. As a precipitant of silver ore, therefore, one gram of pure covellite is capable of depositing 2.26 grams of silver in the form of silver sulphide. On the other hand, one gram of pure chalcocite is capable of precipitating 2.7 grams of silver, one-half of which is combined with sulphur as silver sulphide and the other half is free silver.

Conspicuous among the more complex sulphides commonly associated with native silver is bornite. The mineral contains copper, sulphur and iron, but its chemical composition has

[1] Published by permission of the Director of the United States Geological Survey.

[2] Palmer, Chase, and Bastin, Edson S., Metallic minerals as precipitants of silver and gold. Economic Geology, **8**: 140–170. 1913.

[3] Pogg. Annalen der Physik, **152**: 471. 1874.

[4] Journal f. prak. Chemie, **10**: 353. 1837.

not been definitely settled. Analyses of bornite from different sources have led to several empirical formulas for it, such as,

$$Cu_3FeS_3,\ Cu_5FeS_4,\ \text{and}\ Cu_{12}Fe_2S_9.$$

The constitution of bornite has been a favorite subject of speculation. The views of Rammelsberg and Groth illustrate the vacillations and uncertainties likely to follow sole reliance on composition as indicative of constitution. In 1841 Rammelsberg assigned to bornite the constitutional formula, $3Cu_2S.Fe_2S_3$, by which all the copper is represented as present in the cuprous state. Later he considered all the iron of bornite to be ferrous iron and the copper to be partly cuprous and partly cupric, and to express these supposed conditions he ascribed to bornite the constitutional formula, $Cu_2S.CuS.FeS$. Groth has considered bornite to be strictly a cuprous substance and has adopted the formula, $3Cu_2S.Fe_2S_3$ which Rammelsberg had abandoned.

It has been known for a long time that bornite immersed in a silver nitrate solution quickly develops on its surface a crop of silver crystals, but beyond the mere appearance of silver on bornite this striking phenomenon seems to have received no attention from mineralogists. Believing that a study of the capacity of bornite as a silver precipitant might throw light not only on the chemical composition of the mineral, but also on the intramolecular relations of its constituents, the reaction of a specimen of bornite from Virgilina, Virginia, and dilute silver sulphate solution has been studied quantitatively. The specimen was massive, its freshly broken surfaces having a uniform color. Metallographic examination of polished surfaces showed the presence of a few small grains of chalcopyrite and a few gashes of a dark grey mineral suggestive of chalcocite. The mineral was broken into small fragments, and from these were chosen only those pieces in which, under the magnifier, no chalcopyrite could be detected. The granular pieces were washed with alcohol, and from these a second selection of bornite was made. In this way, it was believed, material representative of the true bornite in the specimen was obtained. An analysis of the material selected for study gave the content

				Atomic ratios
Copper	62.50 per cent	62.50 ÷ 63.4	= 0.986	4.74
Iron	11.64 per cent	11.64 ÷ 56	= 0.208	1.00
Sulphur	25.40 per cent	25.40 ÷ 32	= 0.794	3.81
	99.54			

These results agree fairly well with the requirements of the empirical formula Cu_5FeS_4. The relatively high proportion of iron suggests the presence of a small quantity of chalcopyrite which in preparing the sample for study had escaped detection.

EXPERIMENT WITH SILVER SULPHATE SOLUTION

The finely ground mineral (0.5926 gram) was digested first on the steam bath for 6 hours and afterwards at room temperature. After 12 hours the solution was filtered from the insoluble material. From the deposit were obtained 0.5983 gram of free silver and 0.6037 gram of combined silver. Traces of copper were present in the residue which also yielded

0.0643 gram iron = 10.85 per cent of the mineral.
0.1478 gram sulphur = 24.94 per cent of the mineral.

and from the solution were obtained

0.3615 gram copper = 61.00 per cent of the mineral.
0.0053 gram iron = 0.89 per cent of the mineral.

Atomic proportions of the copper dissolved by the silver solution and the iron and sulphur recovered from the residue:

	Per cent		
Copper	61.00	÷ 63.4	= 0.962
Iron	10.85	÷ 56.0	= 0.193
Sulphur	24.94	÷ 32.0	= 0.780

and

				Cu		Fe		S
0.962	:	0.193	:	0.780 =	4.98	:	1.0	: 4.04.

The results obtained by this chemical reaction approximate the requirements of the empirical formula, Cu_5FeS_4, more closely than do the results obtained by a gross analysis of the sample.

Atomic proportions of the dissolved copper and the precipitated silver products:

	Per cent		
Dissolved copper	61.00	÷ 63.4	= 0.962
Free silver	100.9	÷ 107.9	= 0.935
Combined silver	101.8	÷ 107.9	= 0.943

and

				Copper		Free silver		Combined silver
0.962	:	0.935	:	0.943 = 1.00	:	0.97	:	0.98

This experiment shows that for every atom of copper dissolved by the silver sulphate solution one atom of free silver and one atom of combined silver in the residual material are deposited. It is apparent, therefore, that the copper of this bornite is cuprous just as it is in chalcocite and to express the cuprous nature of the copper it is convenient to use for this bornite the formula $5Cu_2S.Fe_2S_3$ after the dualistic system. This formula may be considered a constitutional formula for the mineral under examination, and its corresponding molecular formula becomes $Cu_{10}Fe_2S_8$.

The proportional amounts of the substances participating in this reaction of bornite may, therefore, be expressed by the equation:

$$Cu_{10}Fe_2S_8 + 10Ag_2SO_4 = 10Ag + Ag_{10}Fe_2S_8 + 10CuSO_4$$

Thus one gram of this bornite is capable of precipitating 2.15 grams of silver as silver and silver sulphide. In strong contrast with the reactivity of its cuprous constituent is the inertness of the sulphoferric portion of the bornite.

Inasmuch as the group, Fe_2S_3, is not known to exist as an independent mineral, the formation of a silver ferric sulphide as one of the products of the reaction of bornite with silver sulphate solution may be presumed. Moreover, from the stability of the compound residual products it seems not improbable that in regions abounding in silver deposits associated with bornite some silver sulphoferric mineral as a secondary product may yet be found. It is hoped that further study of the conduct of copper iron sulphide minerals with silver salt solutions will shed light on the chemical relations which sternbergite and its allied minerals bear to one another.

BOTANY.—*New or imperfectly known species of bull-horn acacias.* WILLIAM EDWIN SAFFORD, Bureau of Plant Industry.

In 1914 the writer published a preliminary paper on the myrmecophilous acacias of tropical America commonly called bull-horns.[1] The present paper is intended as a supplement to it. Additional material has been received from various sources, including specimens from the herbarium of the Missouri Botanical Garden collected in Mexico by Dr. Josiah Gregg in 1849, and others from the Isthmus of Panama, collected recently by Mr. Henry Pittier.

An undescribed species very closely related to *Acacia Standleyi* and to *A. hirtipes* must be assigned to the section Clavigerae. The fact that the large spines of this new species are quite glabrous makes it advisable that the group name Hebacanthae, which includes these species, be changed; and the name Mesopodiales is therefore proposed herewith as a substitute for it. As modified the group may be redescribed as follows:

Group V. MESOPODIALES (*Hebacanthae* Safford, op. cit., p. 366). Involucel borne at or above the middle of the peduncle of the flower spike. Interfloral bracteoles not peltate, but composed of a fan-shaped or ovate limb with a hairy margin, borne upon a slender pedicel and forming an imbricated pubescent covering over the flowers before anthesis.

Of the three additional species discussed one belongs to the group Ceratophysae and two to the Globuliferae.

Acacia dolichocephala Safford, sp. nov. Group Ceratophysae, section Dolichocephalae. A shrub or small tree resembling *Acacia sphaerocephala* Schlecht. & Cham., but readily distinguished by its elongate flower-heads and fusiform receptacle, as well as by the occasional presence of nectar glands on the leaf-rachis at the base of the terminal and subterminal pairs of pinnae. Young growth puberulent, at length glabrate. Stipular spines ivory white, tipped with brown, broadly divergent and slightly curved outward, terete, tapering gradually to a point, the bases flattened and more or less cuneate, the spines 4 to 5 cm. long, 10 to 12 mm. broad along the line of union of the connate bases. Leaves of vegetative branches composed usually of 10 pairs of pinnae; rachis puberulent, 10 to 14 cm. long, with an elongated

[1] Safford, W. E., "*Acacia cornigera* and its allies." Journ. Wash. Acad. Sci. 4: 356–386. 1914.

crater-like nectar gland on the petiole a little below the first pair of pinnae, often a second, tubular gland below the second pair, and sometimes a gland at the base of the terminal and subterminal pairs of pinnae; leaflets 22 to 26 pairs, assuming a reddish bronze color when dry, oblong-linear, 8 to 10 mm. long, 2 mm. broad, unequal at the base, rounded at the apex and mucronulate, those from which apical food bodies have fallen retuse; midrib prominent beneath, oblique; lateral nerves inconspicuous. Leaves of the flowering branchlets composed of 2 to 5 pairs of pinnae; leaflets 8 to 14 pairs, 3 to 4 mm. long; rachis of leaf with a conspicuous raised nectar gland just below the lowermost pair of pinnae, and frequently a smaller gland at the base of the terminal pair of pinnae. Flowers in ovate-oblong heads or spikes 11 to 15 mm. in length and 8 mm. in diameter at anthesis, usually in clusters of 2 or 3, rarely solitary or in clusters of 4; peduncles graduated in length, thick and fleshy, dark reddish brown, the longest equal in length to the fusiform axis of the head or exceeding it, the shortest less than half as long; involucel 4-toothed, calyx-like, situated at or near the base of the peduncle, puberulent without. Flowers ferrugineous, tubular; calyx 1.9 to 2.1 mm. long, 0.5 to 0.6 mm. in diameter, densely puberulent about the margin, obtusely and shallowly 5- or 6-lobed; corolla scarcely exceeding the calyx; stamens numerous, with ferrugineous filaments and pale tan-colored anthers; pistil filiform. Pedicelled bracteoles between the flowers with obtuse ovate ciliate laminae, these puberulent on the upper surface; pedicels 1.4 mm. long, when young clothed with sparse short diaphanous hairs, at length glabrate. Pods resembling those of other Ceratophysae, inflated, indehiscent, thin-chartaceous, 3.5 to 4 cm. long, 1 cm. in diameter, wine-colored when mature, cylindrical, often slightly oblique, terminating in a sharp spine-like beak, and contracted at the base into a short stipe-like neck.

Type in the herbarium of the Field Museum of Natural History, no. 189552, including flowers and mature seed-pods, collected along the shore north of the city of Vera Cruz, Mexico, January 24, 1906, by Dr. J. M. Greenman (no. 87). A specimen of the type collection with less perfectly developed spines and without seed-pods, is in the United States National Herbarium, no. 692164.

Acacia chiapensis Safford, sp. nov. Group Globuliferae, section Ramulosae. An erect shrub or small tree 3 to 5 meters high, resembling *Acacia Donnelliana* but distinguished from that species by the absence of interpinnal nectar glands on the larger leaves and by the more numerous glands at the base of the leaf rachis (petiole). Young growth puberulous. Flower heads globose, borne in axillary clusters on special flowering branches (only very young flower heads observed in the type specimen), covered before anthesis by the imbricate peltate limbs of the pedicelled interfloral bracteoles. Fruit (immature in the type material) a flat strap-shaped legume, somewhat thickened at the sutures, 7.5 to 7.8 cm. long, 7 to 8 mm. broad, terminating in

an obtuse point and narrowing at the base into a stipe-like neck, several legumes radiating from the indurated torus; fruiting peduncle 1.5 to 2 cm. long and (in the type) as thick as the flowering branch bearing it; seeds 12 to 14. Large spines dark brown, V-shaped, terete, tapering gradually to a sharp point, minutely puberulous near the base, at length glabrous and glossy, 50 mm. long, 5 mm. thick near the base, usually perforated and inhabited by stinging ants. Small spines scarcely exceeding 1 mm. in length, puberulent at the base, terminating in a polished reddish point, in the type not acicular as in *A. Donnelliana*. Leaves of the vegetative branches composed of 20 to 26 pairs of pinnae, these 46 to 60 mm. long, sometimes subopposite; leaflets 34 to 44 pairs, linear-oblong, approximate or contiguous, 5 to 5.5 mm. long, 1 to 1.4 mm. broad, usually rounded or obtuse at the apex, unequal at the base, puberulent when young, often spreading nearly at right angles with the rachis of the pinna; main rachis grooved above, puberulent, devoid of nectar glands except at the base, the groove here broader and bearing 10 to 12 irregularly disposed nectaries, some of them apparently geminate. Leaves of flowering branches varying greatly in size, the larger ones resembling the vegetative leaves but with fewer pinnae, and like them devoid of interpinnal nectar glands, the succeeding ones sometimes with interpinnal glands between the uppermost pinnae, and the smallest bearing 4 to 6 pairs of more or less rudimentary pinnae, nearly all of them with interpinnal nectar glands; all floral leaves with a row of 4 to 6 prominent nectar glands at the base of the rachis, and with minute stipular spines subtending the calyx-like buds from which issue the flower heads.

Type in the United States National Herbarium, no. 692157, collected near San Fernandino, between Tuxtla and Chicoasen, state of Chiapas, Mexico, January 12, 1907, by Guy N. Collins (no. 164), in association with *Acacia Collinsii* Safford. At the time of collection (the dry season) nearly all the plants were entirely leafless.

This species, which appears to be intermediate between *A. Donnelliana* of Honduras and *A. multiglandulosa* of Panama, has thin flat pods, and its spines are uniformly quite straight. On the specimen collected nearly all the spines were punctured, but very few of them contained ants. Those that were secured occurred not in colonies but as individuals in the spines.

Acacia multiglandulosa Schenck, Repert. Nov. Sp. Fedde **12:** 362. 1913.—Bot. Jahrb. Engler **50:** 480. 1914. Group Globuliferae, section Ramulosae. A shrub or small tree with very long narrow bipinnate leaves, some of them provided with large stout polished dark-colored connate stipular spines, these perforated and inhabited by ants, others with minute inconspicuous subulate spines. Large spines (when living) maroon or dark wine-colored, glossy, widely divergent, straight or very slightly curved outward, stout, terete, somewhat flattened at the base, 40 mm. long, 8 to 10 mm. broad at the base. Small spines at the base of equally large leaves scarcely 2 mm. long, minutely

puberulent at the base (when young), glabrous at the blood red point. Leaves of vegetative branches composed of 23 to 31 pairs of pinnae; rachis 20 to 38 cm. long, broadly grooved, with the raised edges of the groove puberulent, and with a single small nectar gland at the base of each pair of pinnae; groove broadening at the base of the rachis and enclosing 20 to 25 small nectar glands, these arranged approximately in 3 rows, truncate-conoid in form, with a central pore-like opening; rachis of pinnae 30 to 58 mm. long, bearing 25 to 31 pairs of leaflets, these linear-oblong, 5 to 7 mm. long, 1 to 1.1 mm. broad, with only the midrib conspicuous beneath, unequal at the base, and usually obtusely pointed at the apex. Leaves of the flowering branches rudimentary, reduced to small bracts about 1 cm. long subtending the peduncles, bearing minute stipular spines and 4 nectar glands but devoid of pinnae. Flower heads 7 mm. long, 6 mm. in diameter, solitary or in pairs, borne in the axils of the bracts on long erect branchlets composed of many nodes; peduncles 8 mm. long, 0.75 mm. thick, provided with a basal involucre of 4 connate bracts; form of interfloral bracteoles not observed. Fruit lacking.

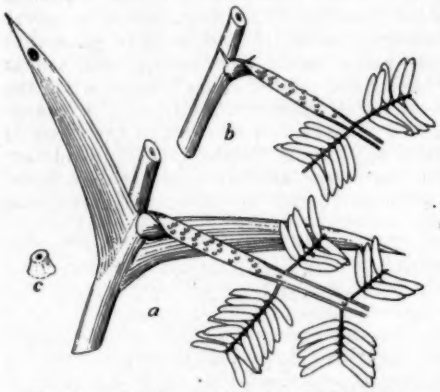


Fig. 1. *Acacia multiglandulosa* Schenck: *a*, enlarged stipular spines, with base of vegetative leaf attached showing numerous extrafloral nectar glands; *b*, leaf base, with minute stipular spines; *c*, nectar gland. Specimen from Panama (*Pittier* 6745). *a* and *b*, natural size; *c*, scale 3.

Type in the Berlin Herbarium, collected at Porto Bello, Panama, in 1825, by J. G. Billberg. It consists of a flowering branch with several flower heads and two disintegrated leaves, but without enlarged stipular spines. Since the publication of Dr. Schenck's paper upon this group fine specimens of vegetative branches with large spines were collected at the head of Gatún Valley, Panama, in 1914, by Mr. Henry Pittier (no. 6745). The latter are now in the United States National Herbarium, sheets no. 716560 and no. 716561.

In its large leaves, composed of many pinnae, this species resembles *Acacia Cookii*; but the presence of many small glands at the base of the rachis separates it at once from that species, and the arrangement of its flower heads on specialized branches instead of in clusters in the axils of large spines places it in the section Ramulosae.

Acacia gladiata Safford, sp. nov. Group Mesopodiales, section Clavigerae. Flower spikes club-shaped, resembling those of *Acacia Standleyi* but much smaller, 10 to 16 mm. long, 4 to 5 mm. thick, densely pubescent before anthesis; peduncles in clusters of 2 to 6, the longest observed 13 mm. in length, pubescent with short straight cinereous hairs both above and below the involucel, the latter normally calyx-like composed of 4 acute ascending teeth, at first densely pubescent on the outside, at length subglabrous and glossy, usually situated at or above the middle of the peduncle; axis of spike not exceeding the peduncle in thickness. Flowers much darker than those of *A. Standleyi*, but apparently yellow after anthesis, on account of the mass of crowded anthers; calyx broadly tubular, shallowly lobed, tan-colored, hairy about the margin and on the sides; corolla maroon or dark wine-colored, obtusely 5- or 6-lobed, about twice as long as the calyx; sta-

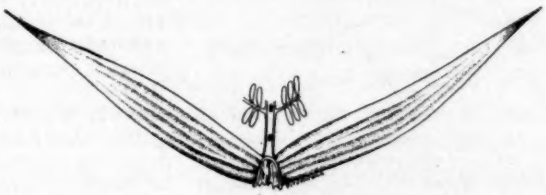


Fig. 2. *Acacia gladiata* Safford. Enlarged stipular spines of vegetative leaf, with base of rachis showing solitary nectar gland. Cotype (*Rose* 3792). Natural size.

mens exserted, very numerous, the filaments ferrugineous, the anthers pale strawcolored; style filiform, longer than the stamens. Fruit not observed. Large spines very long and widely divergent, usually flattened and sword-like, linear-lanceolate in outline, somewhat constricted at the base, resembling certain forms of the spines of *Acacia cochliacantha* H. & B. but connate instead of separate at the base and never split or inflated, gradually narrowed toward the apex to an acute point, 35 to 52 mm. long, 5 to 8 mm. broad, glabrous, reddish or wine-colored when young, at length brown or tan-colored. Leaves with pubescent or minutely hairy rachis and usually with a nectar gland at its base and just below each pair of pinnae, those of vegetative branches 7 to 10 cm. long, composed of about 20 pairs of pinnae, these 23 to 27 mm. long; leaflets about 20 pairs, oblong-linear, 3.5 to 4.5 mm. long and 1 to 1.2 mm. broad, unequal at the base, rounded at the apex, often mucronulate or tipped with a waxy apical body, as in the true myrmecophilous acacias, the margin at first fringed with small stiff hairs, at length subglabrate. Leaves of flowering branches with short subulate stipular spines and 10 to 16 pairs of pinnae; nectar glands circular or oval, with a raised annular margin.

Type, bearing flowers and old spines, in the herbarium of the Missouri Botanical Garden, no. 46838, collected in the vicinity of Rosario, state of Sinaloa, Mexico, in 1849, by Dr. Josiah Gregg (no. 1135). It is mounted on the same sheet with specimens of the spoon-thorn acacia, *A. cochliacantha* H. & B.

Cotype, a young branch with spines and leaves but without flowers or fruit, in the United States National Herbarium, no. 716563, collected near Acaponeta, Territory of Tepic, Mexico, July 30, 1897, by Dr. J. N. Rose (no. 3792.)

This species is closely allied to *Acacia Standleyi* and to *A. hirtipes*, but differs from them both in its smooth, flattened, sword-shaped spines, and in the form and color of its flowers. Though many of the leaflets of the flowering branches are tipped with food bodies, as in the true myrmecophilous acacias, the spines are much compressed and, in the specimens observed, not inhabited by ants.

ECONOMICS.—*Efficiency as a factor in organic evolution. I.*[1]

ALFRED J. LOTKA.

In an earlier issue of this JOURNAL[2] the writer published a paper on *Evolution in discontinuous systems*. In the first portion of this paper the treatment of the subject was quantitative, and made use of analytical methods. In the concluding section certain phases of the subject were touched upon, for which at that time no method of quantitative analytical treatment could be suggested.

In the present paper it is proposed to resume the thread of the former discussion, and to show how the qualitative analysis of the problem then suggested has since fulfilled the author's hopes in furnishing the basis for quantitative treatment.

To recall briefly the point of view adopted in the paper cited, we note that r, the rate of increase per head of a given type or species of organisms, under given conditions, may be regarded as a quantitative *index* of the *fitness* of such species, or of its *adaptation* to the conditions given.

The value of this index r of the fitness, depends, of course, on the one hand, on the external conditions; on the other hand

[1] Paper read before the Washington Philosophical Society on February 13, 1915.

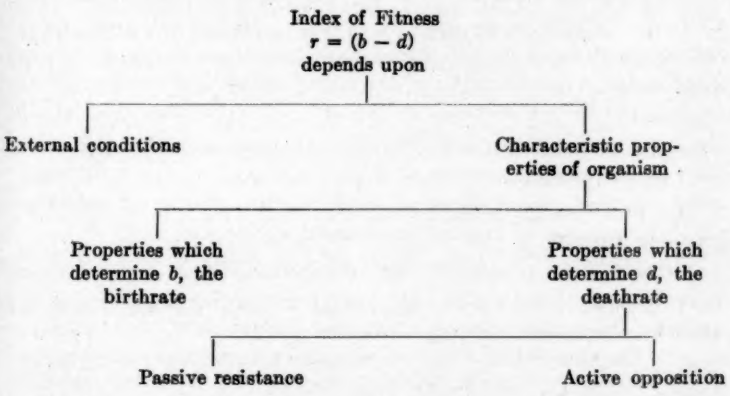
[2] This Journal, **2**: 2, 49, 66. 1912.

it depends on the properties or characteristics of the type of organism.

These properties may be divided into two classes, viz., those which influence r through b, the birthrate per head, and those which do so through d, the deathrate per head.

The latter set of properties can be further subdivided into a class which we may group together collectively as constituting the means of *passive resistance* of the organism,[3] as exemplified, for instance, by such defensive structures as the shell of the tortoise; and another class which we may similarly denote collectively as the means of *active opposition* to circumstances unfavorable to the life of the individual and the species. These latter means comprise that system of sense and motor organs, with a controlling and coördinating nerve-apparatus, which is characteristic of animals, especially of the higher animals, and notably of man.

These facts are summarized in tabular form below:



For the purposes of our present discussion we shall regard the external conditions as given, and shall concern ourselves only with the properties of the type of organism under consideration.

[3] For details the reader must be referred to the previous paper cited.

Moreover, we shall not, on this occasion, discuss those properties which relate to the birthrate.[4]

And again, of the properties which determine the deathrate, we shall suppose the *passive resistance* of the type of organism under consideration as given, and shall devote our attention solely to the analysis of that *mechanism* or, to use a phrase that does not invite fruitless controversy, that *system*, which constitutes the individual's means of active opposition to unfavorable influences. We shall study the relation which the *efficiency* or *precision* of this mechanism or system bears to the fitness (gauged by r) of a given type of organism.

As regards this mechanism or system, it was pointed out in the paper cited above, that all the actions of the organism form part of a cycle, the so-called sensory-motor cycle, or, better, receptor-effector cycle.

For, every action is more or less directly conditioned by sense impressions received by the organism. Between the impression or impressions received and the action or actions conditioned thereby various steps may intervene. In the simplest case a reflex action may be the direct and immediate result of a sense impression. In other cases the action may lag far behind the impression or impressions to which it is referable, and among the intervening steps that lead from the impression to the action may be certain phenomena which form objects of the individual's consciousness, phenomena of will[5] (desire, choice or selection) and phenomena of mentation (logical deduction, etc.)

The efficiency of the receptor-effector system, and hence the

[4] It is hoped to develop this phase of the subject at a later date along lines which have been suggested by the method here laid down.

[5] It is not intended here to open up a discussion regarding the question of free will. All that is meant to be implied by the expression "selection" is that the individual has a *consciousness*, a *sensation* or a *belief* of making use of a specific faculty commonly denoted by the word *will*, in determining which of two or more seemingly possible courses presented to him is to be followed. We are not here concerned with the nature of this faculty of will, but only with the comparison, as regards their *fitness*, of two or more types of organisms, alike in all other respects, but differing in the particular manner in which they effect their *selection;* that is to say, differing in the particular type of their will; or, in other words, differing in their *sense of value*.

fitness of the individual, it was pointed out, depends on the various errors to which he is prone in each of the three fundamental steps of the receptor-effector cycle:

1. In the receptor step:	Errors of observation.
2. In the intermediate step:	a. Errors of mentation (errors against logic, etc.)
	b. Errors of valuation, i.e., errors in the *choice* among several (seemingly) possible actions, i.e., departures from that choice which would make r a maximum.[6]
3. In the effector step:	Errors of operation.

Qualitatively our analysis may be said to be completed when we have thus recognized the several factors that enter into

[6] On this point the reader is referred to the author's paper "An Objective Standard of Value Derived from the Principle of Evolution," this Journal, volume IV, 1914, pp. 409, 447, 499.

The writer wishes to take this opportunity to correct an error which has crept into the paper cited—an error which does not, however, in any way affect the main conclusions of that paper, as applied to our present purposes.

A constant has by an oversight been dropped out of equation (27), pp. 448 and 449. For, after k' had arbitrarily been made equal to unity (equation (20)) we were no longer at liberty to select *labor* as the standard commodity; or, vice versa, if it is deemed convenient so to select our standard commodity, then k' cannot be made unity, but must appear in equation (27), which should thus read

$$v_L = k' \frac{\partial r}{\partial L} = -1 \qquad (27a)$$

This unfortunately means that the indirect method suggested in the paper cited, for establishing the actual numerical ratio between the theoretical (objective) and the practical standard of value, fails, and we are driven back to the resort of actually determining $\frac{\partial r}{\partial x}$ for at least one commodity. The prospects of this being accomplished in the near future seem somewhat slender, though there is one special case in which something can perhaps be done. The writer may have occasion to return to this point in a later communication.

In point of fact it is more convenient to adopt the first of the two alternatives mentioned above, to discard the use of labor as the standard commodity, and to put $k'=1$, so that

$$v_x = \frac{\partial r}{\partial x} \qquad (27b)$$

This is the convention here followed.

play in the operation of the receptor-effector system, and have grasped their bearing upon the fitness of the organism.

Quantitatively our problem may be stated in this form:

If r is the rate of increase per head per annum of a given type or group of organisms, it is required to find a mathematical expression, in terms of suitably chosen characteristic properties of the organism and of the system of which it forms part, for

$$\frac{\partial r}{\partial \epsilon} \tag{1}$$

where ϵ denotes an error of a specified kind, either of observation, operation, mentation or valuation.

At the time when the tabular statement of the qualitative analysis recapitulated above was first given, this was done in the hope that such a provisional analysis might be found to furnish the basis for a quantitative treatment of the subject. This hope has since been realized, although it has been found that in a sense the analysis had been carried too far. In order to make any headway we must now in a measure retrace the steps of our analysis, and recombine some of the threads which we had unraveled.

Let us note first of all that it is not so much isolated and perhaps peculiar actions which interest us, but rather those systematic actions which are of a more or less regular or routine occurrence and which are aimed to meet some more or less permanent demand. In such case, we can say in mathematical terms that the actions in question serve to maintain a certain parameter X_j at a value x_j (for example x_j may be the annual production and consumption of wheat, or the deathrate from malaria etc., etc.).

Disregarding, then, isolated and peculiar actions (which upon reflection are found to constitute at most only a small proportion of the activities of the organism), we may describe in a clear quantitative way the general scope of the activities of a given type of organism, such as man, by stating that the representative individual of that type so distributes his labor, that

$$\left.\begin{array}{l}\text{labor } L_1 \text{ is spent in maintaining a parameter } X_1 \text{ at the value } x_1\\ \text{labor } L_2 \text{ is spent in maintaining a parameter } X_2 \text{ at the value } x_2\\ \qquad\qquad \text{etc., etc., etc., etc., etc.}\\ \text{labor } L_j \text{ is spent in maintaining a parameter } X_j \text{ at the value } x_j\end{array}\right\} \quad (2)$$

Now it will immediately be seen that the *fitness* of the individual, his adaptation to his environment, in so far as it depends upon the activities defined as above, will depend on two factors:

1. On the manner in which the individual distributes his labor among the several pursuits indicated or, in other words, on the proportion

$$L_1 : L_2 : \quad . \quad . \quad . \quad : L_j \qquad (3)$$

2. On the *productivity* or *productive efficiency* of the individual in each pursuit, as measured by

$$E_j = \frac{x_j - C_j}{L_j} \qquad (4)$$

$x_j - C_j$[7] being the increment in x_j produced by labor L_j per unit of time.[8]

It will be seen that the factors (1) and (2) correspond in a way to certain points in our tabular analysis of the influence of various errors on the efficiency of the individual. But instead of considering individual errors we have lumped them together in a statistical way, so that errors of observation and operation find their expression in the corresponding values of the productive efficiencies (which are of course diminished by every such error), while errors of valuation find their expression in the proportion

$$L_1 : L_2 : \quad . \quad . \quad . \quad : L_j$$

[7] The constant C_j is introduced because for some commodities (and for most discommodities) x_j is not zero when L_j is zero, i.e., some of the commodity "grows" spontaneously without the intervention of the interested individual.

[8] In case X_j is of the nature of a "discommodity," E_j is of course negative, as in the case of the example cited above, namely, if X_j is the deathrate from malaria.

While we have thus lost something of the detail of our first analysis, we have gained this point, that the quantities with which we are now dealing are clear cut, measurable and, in principle at least, determinable by statistical methods. By their aid we can attack the problem before us by analytical methods; and furthermore, when we have taken the first steps in this direction, we can, if we wish, restore to our analysis some of the detail which we had temporarily sacrificed.

ERRORS OF OBSERVATION, OPERATION, AND MENTATION

We shall deal with these three types of error under one general head, since they have this in common: that they all exert their influence upon r through the *productivity* or *productive efficiency* of the individual.

We have, quite generally,

$$r = r(x_1, x_2, \cdots x_j, \cdots) \tag{5}$$

so that

$$\frac{\partial r}{\partial E_j} = \frac{\partial r}{\partial x_j} \cdot \frac{\partial x_j}{\partial E_j} \tag{6}$$

In the particular case that the parameter X_j is of the nature of mass produced (and consumed) per unit of time (e.g. the annual production and consumption of wheat), $\frac{\partial r}{\partial x_j}$ is the objective value[9] v_j per unit mass of the commodity X_j. In any case, we can, with obvious economic significance, write

$$\frac{\partial r}{\partial x_j} = v_j \tag{7}$$

Also, from (4) we have

$$\frac{\partial x_j}{\partial E_j} = L_j \tag{8}$$

so that (6) becomes

$$\frac{\partial r}{\partial E_j} = v_j L_j \tag{9}$$

[9] This Journal, 1914, loc. cit.

We have obtained this result by lumping together in a statistical way errors committed by the individual, and dealing not directly with variations in these errors but with corresponding variations in the productive efficiency E_j. There is now no difficulty in carrying our analysis farther, so as to make it correspond in matter of detail more nearly with the qualitative analysis from which we started. We may proceed as follows:

Let I be some suitable parameter which can serve as an index of the imprecision of a particular type of observation or operation. (Thus I may be the mean error made in a particular type of observation or operation; or it may be, for example, the strength of the correcting lens worn by a short-sighted person; or yet again it may be a suitable index measuring the acuity of the logical faculties of the type under consideration, say, something of the nature of a refined Binet test).[10]

Then if i is the value of the parameter I, we have

$$E_j = \varphi(i) \tag{10}$$

$$\delta r = \frac{\partial r}{\partial i}\,\delta i \tag{11}$$

$$= \sum \frac{\partial r}{\partial E_j} \cdot \frac{\partial E_j}{\partial i}\,\delta i \tag{12}$$

the summation being carried over all those parameters X, for which the productive efficiency is affected by the imprecision I.

Hence, by (9)

$$\delta r = \sum v_j\, L_j \frac{\partial E_j}{\partial i}\,\delta i \tag{13}$$

or

$$\frac{\partial r}{\partial i} = \sum v_j\, L_j \frac{\partial E_j}{\partial i} \tag{14}$$

which we interpret, in view of (7) as

$$v_i = \sum v_j\, L_j \frac{\partial E_j}{\partial i} \tag{15}$$

[10] Compare C. B. Davenport, Heredity in Relation to Eugenics, 1911, p. 9.

The quantity v_i in equation (15) has an interesting economic significance. It is the (negative) value, per unit, of the *imprecision* denoted by the parameter I. Thus if I is short-sightedness, measured, say, in dioptries of the correcting lens, then $v_i\ \delta i$ is the (annual) loss in values (commodities) which would be suffered, per head, if all individuals had their short-sightedness increased by a small increment δi, all other things remaining the same.

Or, putting it in another way, $v_i\ \delta i$ is the *fair compensation*[11] which should be paid, per head, to a community in which each individual had his eyesight injured by the (infinitesimal) increment δi, in order to restore to them the total earnings (measured in real commodities) which they made prior to the injury.

Equations (9), (14), and (15) represent the solution of the problem of finding an expression for the differential coefficient (1), so far as errors of observation, operation and mentation are concerned.

[11] To prevent any possible misunderstanding, it must here be pointed out that we cannot, along the lines here given, establish an exact expression for the *fair compensation* corresponding to an injury δi for the case of one individual so injured and competing with others not injured.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEODESY.—*Triangulation in Alabama and Mississippi.* WALTER F. REYNOLDS, U. S. Coast and Geodetic Survey Special Publication No. 24. Pp. 71. 1915.

This publication contains the positions and descriptions of nearly 600 triangulation stations in Alabama and on the Gulf coast of Mississippi. The primary stations included in the volume are a part of the Eastern Oblique Arc, the field work of which was completed in 1898. The results of that triangulation appeared in Special Publication No. 7 in 1901, the positions being on the same datum as that used for the Transcontinental Triangulation, the results of which appeared in Special Publication No. 4. Since that time the United States Standard Datum, now called the North American Datum, was adopted and it became necessary to change the old positions to that datum.

The field work of the triangulation was done between the years 1848 and 1911. Many of the stations of the early surveys are lost, but from time to time tertiary triangulation has been done along the coast to supplement the triangulation of the Oblique Arc.

The elevations of the triangulation stations in Alabama appeared in Special Publication No. 7, but the elevations of several of the stations have since been determined by precise leveling and are now held fixed in a rigid adjustment since made of all the elevations. In this adjustment are also included the elevations of a number of stations in Georgia and Tennessee. On account of the new adjustment of the net, the elevations appearing in this publication will differ slightly from those in Special Publication No. 7.

As a full discussion of the errors and the accuracy of the triangulation of the Eastern Oblique Arc appeared in Special Publication No. 7, it was not considered necessary to give any discussion of these subjects in the new work. There is a table comparing the accuracy of the triangulation in this volume with that of the entire Oblique Arc.

Aside from its scientific interest this volume has a large practical value, as it offers to the engineer a large number of points determined trigonometrically and correlated on one geodetic datum. If the engineer wishes to extend this triangulation or to base other surveys upon it, the positions, descriptions, and sketches given in this volume will supply the data that he will need. W. F. R.

GEOLOGY.—*A gold-platinum-palladium lode in southern Nevada.* ADOLPH KNOPF, U. S. Geol. Survey Bull. 620-A. Pp. 1–18. 1915.

The ore of the Boss gold mine in the Yellow Pine mining district, Clark County, Nevada, has recently been shown to be rich in platinum and palladium. The deposit consists of a fine-grained quartz mass, which constitutes an irregular siliceous replacement of Carboniferous dolomites along a series of vertical fractures. The main ore shoot, in which from 1000 to 2000 tons had been developed at the time of visit, averaged in ounces to the ton: Gold, 3.46; silver, 6.4; platinum, 0.70; palladium, 3.38. The precious metals are especially associated with the rare mineral plumbojarosite, $Pb\,[Fe\,(O\,H)_2]_6\,(SO_4)_4$; pockets of this mineral carry 100 or more ounces of palladium and platinum and several hundred ounces of gold to the ton. The only sulphide so far found in the mine is chalcocite, and this is probably of secondary origin. The occurrence of platinum and palladium in this Nevada gold ore is of some interest, inasmuch as a review of the known distribution of platinum in veins shows that the Boss vein is one of the few primary deposits in which metals of the platinum group are present in more than traces, and, with one possible exception—the New Rambler deposit in Wyoming—is the only primary deposit of economic importance in which these metals are the constituents of predominant value. A. K.

ZOOLOGY.—*The crinoids collected by the Endeavour between Fremantle and Geraldton (Western Australia).* AUSTIN HOBART CLARK. Records of the Western Australian Museum and Art Gallery, 1^3: 113–129. 1914.

A detailed description is given herein of the specimens of each of the twelve species of crinoids which were obtained by the "Endeavour" off southwestern Australia. Of these twelve species one (*Capillaster sentosa*) was not previously known from Australia, while two (*Neometra gorgonia* and *N. conaminis*) represent a family (Calometridae) heretofore not reported south of the Sunda Islands. A. H. C.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 539th meeting of the Biological Society of Washington was held at the Cosmos Club, Saturday, April 3, 1915, with President BARTSCH in the chair and 65 persons present.

On recommendation of the Council, Mr. Ben Miller was elected to active membership.

Under heading Brief Notes, L. O. HOWARD called attention to a wasps' nest he had lately seen which was marked by a conspicuous blue streak. In making this nest the wasps had evidently made the blue streaked part out of a blue building paper, instead of making their pulp from the natural wood. Messrs. BARTSCH and LYON referred to the red-headed woodpeckers in the grounds of Freedmen's Hospital, stating that a few birds had remained during the winter of 1914–15, though none had wintered during 1913–14. The species is abundant in the hospital grounds this spring. Messrs. BARTSCH and BAILEY commented upon the scratching of the gray squirrels in the city parks, which Mr. BAILEY said was due to infestation with fleas from their winter boxes. Suitable insect powder placed in the boxes would drive out the fleas but was not relished by the squirrels.

The first paper on the regular program was by Dr. A. H. WRIGHT, of Cornell University. *The snakes and lizards of Okefinokee Swamp.*

Seven snakes of the dry open sandy fields or pine forests of southeastern United States were absent on the Okefinokee Swamp islands. None of the truly Floridan ophidians and saurians were represented. Some forms occurred on the outskirts of the swamp but were wholly wanting within the swamp. The 21 species of snakes and 6 lizards were very variable in scutellation and coloration. Whether the restricted quarters and the incessant warfare and struggle for place caused the wide range of variation is not yet answerable. We had expected to find fixed peculiar stable races or subspecies because of the isolated nature of some of the islands, but segregation has not yet placed a local stamp on any of the reptilian forms. The swamp is the common source of the Atlantic coastal stream, the St. Mary's, and the Gulf affluent, the Suwannee. This factor may have had its influence on the turtles and possibly on the snakes and lizards. The swamp does not appear to be a barrier or boundary line between two decided faunal areas. It is rather a melting pot for many of the supposed cardinal characters of distinction in snakes and lizards.

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Some of the interesting systematic observations are: the non-trustworthiness of the temporal scutellation and coloration in the *Elaphe* group; the need of further study in the *Tropidonotus fasciatus* assemblage; the presence of the *Osceola elapsoidea* and the *Lampropeltis doliatus coccineus* characters in one and the same specimen; the reduction of *Diadophis amabilis stictogenys* to *D. punctatus*: the non-recognition of *Ophisaurus ventralis compressus*; the presence of white-bellied adults and young of *Farancia;* the possibility of *Heterodon niger* as an end phase of coloration and a query as to the loss of the azygous in *Heterodon browni;* the overlapping in scale rows and ocular formulae in *Storeria occipitomaculata* and *S. dekayi*; the fact that no two heads of the *Sceloporus undulatus* specimens had the same plate arrangements; and the unreliability of the mental characters in *Plestiodon,* our specimens of *P. quinquelineatus* falling into two of Cope's major groups, if determined on mental scutellation. (*Author's abstract.*)

Dr. WRIGHT's paper was illustrated by lantern slides showing views of the swamp, of its reptile inhabitants, and of the variations found in certain of the species. His communication was discussed by the Chair and by Messrs. WM. PALMER and HUGH SMITH.

The second and last paper of the program was by Dr. ARTHUR A. ALLEN, of Cornell University, *The birds of a cat-tail marsh.*

Observations on the food, nesting habits, and structure of marsh birds showing the limitations of specialized species as to food, distribution, and power of adaptability and the dominance of generalized forms were made.

Specialization in birds goes hand in hand with a high development of the instincts but with a low degree of intelligence and little adaptability. Generalization of structure on the other hand, occurs with a weaker development of the instincts, greater intelligence, and greater adaptability. The generalized, adaptable species persist through the ages while the specialized, non-adaptable are first to go. This is seen in the birds of a cat-tail marsh.

Seven stages are recognized in the formation of a marsh, represented in the mature marsh by zones of typical vegetation or plant associations, these associations following one another in regular succession. Similar associations and succession can be recognized among the birds, if we group them according to their nesting range in the marsh. Most species are not confined to one association, although reaching their maximum of abundance in it. The generalized, adaptable species have the widest range.

The various associations with their typical birds follow:

I. The Open-water Association: important in supplying forage but with no nesting birds.

II. The Shoreline Association, with the pied-billed grebe, a specialized non-adaptable species.

III. The Cat-tail Association, with the least bittern, coot, Florida gallinule, Virginia rail, sora rail, and red-winged blackbird finding optimum conditions.

IV. The Sedge Association, with the long-billed marsh wren, bittern, swamp sparrow, short-billed marsh wren, and marsh hawk.

V. The Grass Association, with the song sparrow and Maryland yellowthroat.

VI. The Alder-Willow Association, with the green heron and alder flycatcher.

VII. The Maple-Elm Association, with the black-crowned night heron and great blue heron, of the marsh birds, and a great variety woodland species.

Of all these species the most generalized in habit and structure is the red-winged blackbird. It, too, is the most adaptable and is the dominant species in the marsh. (*Author's abstract.*)

Dr. ALLEN'S paper was illustrated by numerous lantern slides from photographs of the marsh, its bird inhabitants, and their homes, and by motion pictures of the least bittern and of the canvas-back and other ducks. It was discussed by Dr. L. O. HOWARD.

M. W. LYON, JR., *Recording Secretary.*

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

At the 481st meeting of the Society, held January 19, 1915, at the Public Library, an address on *The ancient civilization of India* was delivered by SARATH KUMAR GHOSH, a member of the ancient princely house of Ghoshpara, India. About 260 persons were present. The lecturer said that the Aryans settled in India between 6000 and 4000 B. C. There, shut off from hostile neighbors by the mountains on the north and finding a fertile soil, they adopted agriculture, the beginning of civilization. Aryan civilization first began in India. In Europe, much later, the Greeks were the first to become civilized, because they too were protected by mountains. Primitive man had no distinct domestic life. A woman was not even the chattel of a particular man, but common to the community. Later, the man accepted the responsibilities of husband and father. That stage had been already reached when the Aryan race came to India, but it was there that the family became a distinct unit. The mode of government was patriarchal. Later, the heads of families made the laws; the community became a republic. Next, a group of elders were acknowledged as the leaders of the community, constituting an oligarchy. Still later, a man of supreme valor and ability was elected as king, probably at some crisis. Finally, monarchy became hereditary when the Aryans evolved a caste system.

Man first worshipped his tools and weapons; later, the forces of nature. The worship of nature was intensified when the Aryans became agriculturists, as their food depended upon the clemency of nature. The Aryans of the West, even the Greeks and Romans, never progressed beyond this stage. The Hindus, however, evolved a higher religion, worshipping a supreme and omnipotent Deity above the forces of nature. This was about 2500 B. C. By this time the Hindus

had brought their language to the highest perfection. The Vedas, or hymns in praise of the Deity which were then composed, still remain the most exalted poetry in all literature. Some of the composers of the Vedas were women. The Hindus, seeing the dual form, male and female, pervading all the works of Deity, attributed a dual form to Deity itself, and regarded all its gentle qualities as feminine, such as the joy of creation. That was the apotheosis of womanhood. Not only was marriage exalted to a sacrament, but woman's part in it was greater than man's. Upon woman's good will were made dependent man's good deeds (karma), hence, his very salvation. The building of the temple was the beginning of architecture. The priest designed his altar stones after the regular forms in nature—which was the beginning of geometry. Astronomy began when the priesthood designed some star-deity to shine on the altar stone through an orifice in the roof at the moment of sacrifice. In Sanscrit literature the age of life on the earth is estimated to be four million years. Because of this habit of "thinking in millions" European critics brought the charge of gross exaggeration against the Hindus. A code of war was enunciated in the Mahabharata which enjoins upon a combatant to discard a superior weapon if his enemy has an inferior one, and forbids him to take advantage of an enemy in toil—in comparison with which the Hague Conference itself is but a code of savage warfare. Hindu civilization reached its zenith about 600 B. C. Thereupon Manu codified the laws, customs, institutions, and even the canons of art, thus unconsciously sowing the seeds of stagnation and decay.

The Aryans found in India several Turanian races whom they conquered and ultimately allowed to enter their political and social system as a subordinate caste. Only the high-caste Hindus of today are of pure Aryan descent; the masses are generally of mixed descent, in the South, almost entirely Turanian (Dravidian). Long continued immigration from Europe has caused a mixture of blood among the higher castes. Megasthenes, an early Greek ambassador, accorded the highest testimony to Hindu civilization. He noted with admiration the chastity of the women, the valor of the men, and the three stupendous facts that slavery, locks, and falsehood were unknown in India. Still later India taught the arts, philosophy, and religion from Java to Japan. Java and Siam elected Hindu princes as their kings. The present king of Siam is of direct Hindu descent. In the Philippines many words of higher meaning are of Sanscrit origin. There is a possibility of early Hindu influence having reached America, or Patal Desha, the Land of the Antipodes. Further research in Central America and Peru is needed to establish this point.

At the 482d meeting of the Society, held February 2, 1915, Dr. C. L. G. ANDERSON, of the Medical Reserve Corps, U. S. A., read an obituary on Dr. A. F. A. KING, a member of the Anthropological Society, who died in Washington December 13, 1914. Dr. KING was born in Oxfordshire, England, January 18, 1841, and came to Virginia with

his parents when but ten years of age. He received degrees in medicine from the National Medical College, now merged with the George Washington University, and from the University of Pennsylvania. Beginning practice in Virginia, he helped treat the Confederate wounded after the battle of Bull Run. Soon after, he served as Acting Assistant Surgeon, U. S. A., at the Lincoln Hospital, in Washington. In 1870 he became assistant, and later, professor in obstetrics in the National Medical College, and in the University of Vermont, which positions he filled until his death, through a period of 43 years. He is survived by his widow and three children. He belonged to the Anthropological, the Medical and other scientific societies of Washington and also to foreign societies, and made many contributions to medical and scientific literature. His best known work is *A manual of obstetrics*. Among his papers of interest to anthropologists are those on *Hysteria* and *functional reversion*. He read a paper before the Anthropological Society in 1881 on *The evolution of marriage ceremony and its import*. The following year he was elected a member of the Council. He was a man of charming personality, and lived an exceptionally happy, normal, and complete life.

At the 483d meeting of the Society, held February 16, 1915, at the Public Library, a paper was read by Mr. WILLIAM H. BABCOCK on *The races of Britain*, and brief reports were made by Messrs. W. H. HOLMES, J. W. FEWKES, TRUMAN MICHELSON. and J. N. B. HEWITT on *Recent field research in anthropology and ethnology*. Mr. BABCOCK pointed out that three native languages are spoken in the island of Great Britain—English over the greater part of it, Welsh in parts of the western mountains, and Gaelic in the northern mountains—a situation which was the same in the latter part of the sixth century, excepting differences in the area of each. These languages represent three distinct waves of invasion by people who were blond when of pure blood; yet the present population contains a great number of brunets or persons of medium tint, and brunetness seems to be gaining on blondness. The best explanation seems to be that the blond conquerors found in Britain a long established and thoroughly acclimated darker population, which perhaps remained more numerous than the newcomers and certainly was better adapted to permanently transmit its characteristics. This was composed mainly of a fairly advanced neolithic race, probably from southern Europe, with whatever paleolithic stocks may have been absorbed by them. The historic conquests of Great Britain—Roman, Saxon, Danish, and Norman—have not changed the essential result, which consists of a darker substratum gradually gaining on superimposed Celtic and Teutonic layers.

Professor HOLMES outlined the work done recently in California by himself and Dr. ALEŠ HRDLIČKA. The Panama-California Exposition had assigned funds to Dr. HRDLIČKA for the preparation of an exhibit illustrating the physical history and present status of man, and to Professor HOLMES for another illustrating the practice of certain indus-

tries of the American aborigines. The materials gathered by Dr. HRDLIČKA form, it is believed, the most important exhibit within this particular field that has ever been brought together. They were collected largely through expeditions conducted by Dr. HRDLIČKA personally. The exhibits cover, in as many halls, man's evolution, the life cycle of man, man's variations, and human pathology, with dissolution. A large room is fitted out as an anthropological laboratory, lecture room, and library. The exhibit prepared by Professor HOLMES includes six lay-figure groups illustrating: Copper mining on Isle Royal, Michigan; iron and paint mining in Missouri; quarrying and working of soapstone and of obsidian in California; flint arrow makers; and stone cutters of Mitla, Mexico. These are supplemented by collections of the products of aboriginal handiwork and by two cases of casts of the sculptural work of North and South America. The exhibits, which are shown in the Arts and Crafts Building, will probably become part of a permanent museum in San Diego.

Dr. FEWKES made a trip last month primarily to examine two of the possible trails by which prehistoric cultural interchanges between Mexico and our Southwest were effected. These were the valleys of the Santa Cruz in Arizona and of the Mimbres in New Mexico, both extending north and south. The ruins from Tucson to the Mexican border along the Santa Cruz are of the Casa Grande type. The old mission of Tumacacori, south of Tucson, preserved as a national monument, must be attended to within a few years or its walls will fall. The Papagueria, or desert home of the Papagos, is one of the most instructive unexplored regions in the Southwest. In the valley of the Mimbres are ruins showing cultural resemblances between Old and New Mexico. From this valley he brought back a collection of more than 800 specimens, including 250 pieces of painted pottery which, together with specimens brought back last year, open up a new culture area, the character of which was practically unknown before.

Dr. MICHELSON gave an account of his researches among New England Indians now in Wisconsin. There are 600 Stockbridges adjoining the Menominee reservation, for the most part showing mixture of white or negro blood. Perhaps a dozen of these know genuine Stockbridge words. One old man could dictate texts. The material obtained showed that Stockbridge belongs to the Pequòt-Mohegan and Natick division of Central Algonquian dialects, sharing one or two points with Delaware-Munsee. Their ethnology is forgotten. Among the 250 or more Brothertowns near Lake Winnebago, not one was found who could remember a word of his own language. No full bloods were found.

Mr. HEWITT reported concerning his trip last December to Canada on which only one survivor was found who preserved any knowledge of the Nanticoke dialect, a woman taken from the eastern shore of Chesapeake Bay. A particular investigation was made of the purpose and part of song in the ceremonial of an Iroquois lodge.

DANIEL FOLKMAR, *Secretary.*